CHAPTER-03

PLANT KINGDOM

Whittaker classified the whole living organism into five kingdoms based on the complexity of cell structure (Prokaryotic and Eukaryotic), the complexity of the body (unicellular and multicellular), and mode of nutrition (autotrophs and heterotrophs).

CLASSIFICATION OF PLANT KINGDOM:

All the classification systems, starting from that of Aristotle to the 20th century, can be divided into three types- Artificial, Natural, and Phylogenetic.

1. Artificial system: Classification based on few morphological characters.
Theophrastus, Pliny, and Linnaeus used an artificial system of classification.

2. Natural system: Classification based on all the important related characters.
Both external and internal.
Bentham and hooker, Adanson, Candolle used the natural system of classification.

3. Phylogenetic system: Classification based on the evolutionary relationship of plants.
Eichler, Blessy, Whittaker, Engler, and Prantl, Hutchinson used phylogeny.

Numerical taxonomy: Taxonomy is based on statistical methods with equal importance using a computer.
Cytotaxonomy: Taxonomy based on cytology or cell structure (chromosome number, shape, behaviour, etc).
Chemotaxonomy: Taxonomy based on chemical constituents of plants (nature of the protein, DNA sequence, taste, smell, etc).

EICHLER CLASSIFICATION: Classification of Plant kingdom based on flowering.
Divided into two- Cryptogamae (non-flowering, seedless plants)
Phanerogamae (flowering, seed-bearing plants).

Based on the plant body Cryptogamae is divided into **Thallophyta, Bryophyta, and Pteridophyta**.

Thallophyta: Plant body is thallus like (undifferentiated plant body)

Bryophyta: plant body with a root-like structure, stem-like structure, vascular tissues are absent).

Pteridophyta: The plant body is differentiated into true root, stem, and leaves. Vascular tissues are present so-called **vascular cryptogams.**

Thallophytes again divided into
1. Algae (pigmented thallophytes)
2. Fungi (nonpigmented thallophytes)
3. Lichens: Symbiotic association between algae and fungi.

Phanerogamae divided into two :
1. Gymonosperma (naked seed plants) and
2. Angiosperma (covered seeded plants)

Angiosperms are again divided into two
1.Monocots (have single cotyledon, fibrous root system, and parallel venation)
2. Dicots (have two cotyledons, taproot system, and reticulate venation).

Pteridophytes, Gymnosperms, and Angiosperms are called **Tracheophytes due to the presence of vascular tissue.**

Bryophyta, Pteridophyta, Gymnosperms, and Angiosperms are called **Embryophyta as they have an embryo.**

ALGAE:

Phycology: Branch of Biology which deals with the study of algae. Phycos=sea weed Logos=study
Fritch –Father of phycology.
M.O.P.Iyengar is the father of Indian phycology.
Algal members are pigmented thallophytes.
Habitat:
Hydrophytes: Water is their habitat
Xerophytes: In desert habitat
Mesophytes- a plant needing only a moderate amount of water.
Lithophytes- on rocks
Halophytes- in salty areas.
In aquatic habitat-fresh water (*Spirogyra*) and marine (*Sargassum*).
Floating- *Chlamydomonas, Spirogyra*
Benthophytes - (attached to the bottom) –*Chara* (stoneworts)
Epiphyte-growing on plant body *(Cladophora*)
Epizoic-growing on the animal body (*Trichophillus*)
Moist soil-terrestrials (*Fritschiella*).

Plant body:

The vegetative plant body is a haploid gametophyte.
Unicellular, flagellated (*Chlamydomonas*) or non-flagellated (*Chlorella*)
Multicellular:

a) Coenobium-a colony with a fixed number of cells and division of labour. Eg: *Volvox*

b) Filamentous-unbranched. Eg: *Ulothrix*
c) Filamentous branched. Eg: *Cladophora*
d) Parenchymatous. Eg: *Ulva*
e) Branched like higher plants. Eg: *Sargassum, Chara*

Nutrition:

Autotrophs - Photosynthetic (most of them)
Parasitic forms (rare). Eg: *Cephaleuros*.

Pigments:

1. Chlorophyll- a, b, c, d.
2. Carotenoids- carotene and xanthophyll-fucoxanthin (dominating pigment in brown algae).
3. Phycobillins- phycocyanin and phycoerythrin.

Reproduction:

Vegetative reproduction- Reproduction using the vegetative parts.

Different types are

- Fission
- Fragmentation
- Budding
- Tubers
- Gemmae.

Asexual reproduction-without the fusion of gametes.

Mainly by:

- Zoospores(motile as have flagella) within sporangia
- Aplanospores (nonmotile spores)
- Endospore
- Exospore

Sexual reproduction:

- Homogametes-similar gametes
- Heterogametes-dissimilar gametes

• **Isogamy: fusion of morphologically and physiologically similar gametes.**

Isogamy- flagellated (*Chlamydomonas*) and non flagellated (*Spirogyra*).

• **Anisogamy: fusion of morphologically or physiologically dissimilar gametes.**

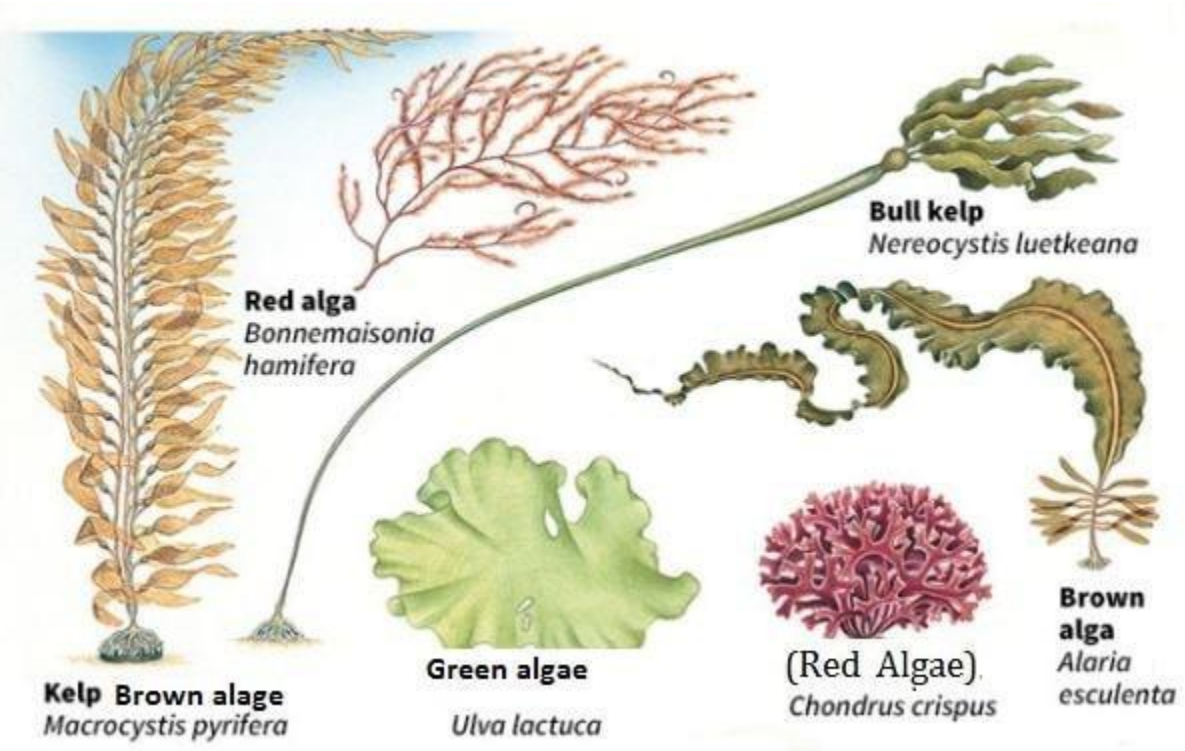
Morphologically dissimilar–eg: *Chlamydomonas*
Physiologically dissimilar –eg: *Spirogyra*.

• **Oogamy**- a fusion of morphologically and physiologically dissimilar gametes. Small motile male gamete + large nonmotile female gamete. Eg: *Fucus, Volvox*.

The life cycle has two phases-haploid and diploid and some of them exhibit **alternation of generation**. The haploid phase alternates with the diploid phase.

CLASSIFICATION OF ALGAE:

• Chlorophyceae
• Phaeophyceae
• Rhodophyceae.



CHLOROPHYCEAE:

The plant body is unicellular as in *Chlamydomonas* or colonial as in *Volvox* or filamentous as in *Spirogyra*.

Different shapes for the chloroplast-

- Ribbon shaped and spiral in *Spirogyra*
- Girdle shaped in *Ulothrix*
- Cup-shaped chloroplast in *Chlamydomonas*
- Photosynthetic pigments are chlorophyll a and b.
- Store food in the form of starch and some store in the form of oil droplets.
- Pyrenoids which are the storage bodies are present.
- The cell wall is made up of an inner layer of cellulose and an outer layer of pectose.

- The members reproduce
- Vegetatively by fragmentation
- Asexually by flagellated zoospores
- Sexually by isogamy, anisogamy, and oogamy.
- Common Chlorophycean members are *Chlamydomonas, Chlorella, Volvox, Ulothrix, Ulva, Chara, Acetabularia,* etc.

BROWN ALGAE OR PHAEOPHYCEAE:

They are marine.

Simple branched and filamentous as in *Ectocarpus*, or flat ribbon-shaped in *Sargassum, Laminaria, Fucus,* etc.

Kelps which are the giant brown algae are the largest sea plants, some are free-floating as in *Sargassum* and some are epiphytes on other plants like *Ectocarpus*.

Plant body has three parts-

- **fixing structures called to hold fast**
- **a stalk-like structure called a stipe**
- **a leaf-like structure called a frond.**

Pigments are chlorophyll a, c, carotenoids, and xanthophylls.
Food is stored in the form of **laminarin and mannitol** which are complex carbohydrates.
The cell wall is made up of cellulose and is covered by a gelatinous coating called **algin** on the
the outer part which is a phycocolloid (hydrocolloid) and they prevents the thallus from drying in low tide.
A cell consists of cell organelles and centrally is the vacuole which helps the thallus to float.
Vegetative reproduction is by fragmentation.
Asexual by biflagellated zoospores which are pear-shaped with two flagella attached laterally.
Sexual reproduction is by the fusion of gametes-

- Isogamy,
- Anisogamy
- Oogamy.
- Gametes are pear-shaped with 2 laterally attached flagella.

The common brown algae are *Ectocarpus, Laminaria, Dictyota, Sargassum,* and *Fucus*.

RHODOPHYCEAEA (Red Algae):

Commonly called as red algae.
They are mostly marine and rarely freshwater.
Eg: *Betrachospermum*.
They occur in the well-lighted region and also in depths of oceans.
The thallus is multicellular.

Pigments present are chlorophyll a, d and phycoerythrin.
The red colour is due to the presence of a red pigment called **r-phycoerythrin.**
Food is stored in the form of **floridean starch which is similar to amylopectin and glycogen** in structure.
Vegetative reproduction by fragmentation
Asexual by nonmotile spores
Sexual by Oogamy and has complex post-fertilization developments.
The common red algae are *Polysiphonia, Porphyra, Gracilaria, Gelidium, Betrachospermum,* etc.

Economic Importance of algae:

- Algae are the primary producers in the food chain. They form the basis of the food cycles of all aquatic animals.
- Half of the total carbon dioxide fixation on earth is carried out by algae by photosynthesis.
- Helps in the purification of air and water.
- Some are edible. Eg- *Chlorella, Spirulina, Laminaria, Porphyra, Sargassum, Ulva*
- Some are used as fodder. Eg; *Laminaria, Sargassum, Fucus*.
- Food supplement for space travellers like *Chlorella, Spirulina*,
- Hydrocolloids or water-holding substances like algin and carrageen are obtained from red algae.
- Agar is obtained by *Gelidium* and *Gracilaria*. It is used to grow microorganisms.
- Used in the preparation of culture media in tissue culture experiments.
- Medicinal- Antibiotics. Eg: *Chlorella, Polysiphonia*.
- Source of minerals- *Polysiphonia, Laminaria*
- Biological research: *Chlorella, Acetabularia*.

Common names of algae:

- Water silk-*Spirogyra*
- Sea lettuce- *Ulva*
- Umbrella plant-*Acetabularia* (Largest unicellular algae)

BRYOPHYTES:

Simplest non-vascular land plants with undifferentiated plant body.
Bryology-Study of Bryophyta
Hedwig- Father of bryology
S.R.Kashyap-Father of Indian bryology
Bryophytes are known as the amphibians of the plant kingdom.
Bryophytes grow in dense patches on the moist shady places like walls, damp soil, tree trunks, etc.

Features:

Habitat: Mainly terrestrial
Some are aquatic .E.g- *Riccia fluitans*

Epiphyllous –E.g*: Radula*
Plant body-
Thallus like and Prostrate.Eg: *Riccia, Anthoceros, Marchantia* or
Erect. Eg- Moss.
Root like structures called **rhizoids** fixes them to the soil.
The plant body is differentiated into stem-like and leaf-like structures.
Vascular tissues are absent.

Vegetative reproduction by fragmentation, budding, tubers, that, etc.
Asexual by Gemmae- asexual buds in liverworts.
The sexual reproduction-The vegetative plant body is the gametophyte and all members are homosporous.
Multicellular sex organs present and are found in clusters.
Male reproductive organs are the club-shaped antheridium and the female part is the flask-shaped archegonium.
Anthredium produces biflagellated antherozoids which are motile and archegonium produce the egg.
Antherozoid fuses with the egg to form the zygote.
The sporophyte is not free-living and it derives nourishment from the photosynthetic gametophyte.
Haploid spores are formed in the sporophyte after meiosis and the spore germinates to form the gametophyte.
Alternation of generation present- haploid phase alters with the diploid phase.
Both phases are multicellular.
The dominant photosynthetic free-living stage is gametophyte.
The sporophyte is short-lived and depends on the gametophyte. Water is essential for fertilization.

Classification of Bryophytes:

- 1.Hapticospida (liverworts)
- 2.Anthocerotopsida (Hornworts)
- 3.Bryopsida.(Moss)

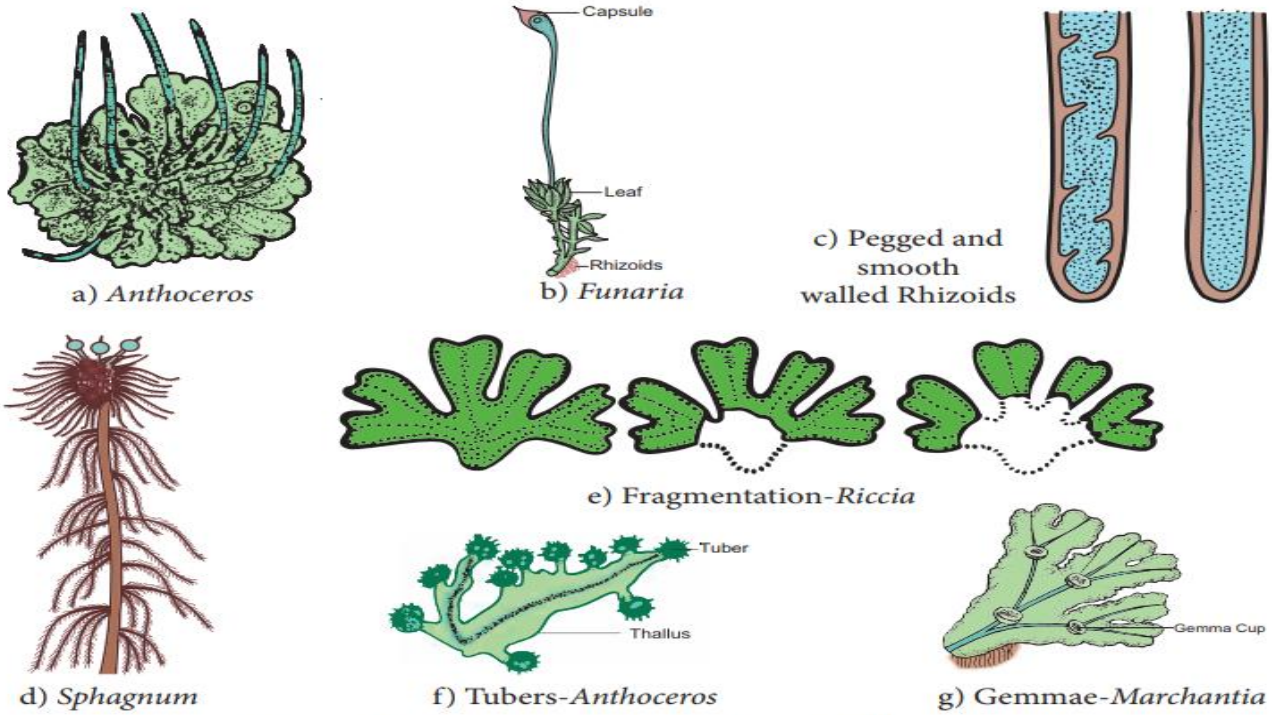


Figure 2.11: Structure and reproduction in Bryophytes

HEPATICOPSIDA OR LIVER WORTS:

The plant body is photosynthetic, flat, dorsiventral thallus .E.g.: *Riccia, Marchantia*
The rhizoids help the thallus to get attached to the soil.
Vegetative reproduction is by fragmentation. E.g.: *Riccia, Marchantia*
In some bryophytes, by the gemmae formation. E.g.: *Marchantia*
Gemmae are green multicellular, asexual buds that develop into small receptacles called gemma cups.

It gets detached from the parent body and germinates to form the new thallus.
Sexual reproduction: Sex organs are **antheridia and archegonia**. They are formed either on the same thalli or different thalli.
The sporophyte is differentiated into three parts-**foot, seta, and capsule.** Meiosis takes place in the capsule to form the haploid spores which germinate into a free-living thalloid gametophyte.
Antheropsida or Hornworts: E.g.: *Anthoceros, Notothylas*.
Anthoceros is commonly known as hornworts
They contain pyrenoids.
Symbiotic nitrogen fixation is present.

BRYOPSIDA (MOSS):

They are higher bryophytes
The gametophyte consists of two stages-**protonema and leafy stage**.
Protonema are green filamentous, branched, creeping structures directly developed from the spore on
germination and they bears branched rhizoids and lateral buds.
The leafy stage is developed from the secondary protonema as a lateral bud.
The plant body consists of root-like, stem-like, and leaf-like structures. Eg: *Funaria*.
Rhizoids are multicellular and branched. Leafy stages bear the sex organs.
Vegetative reproduction takes place by fragmentation and budding in the secondary protonema.
The spore dispersal mechanism is elaborate in mosses.
Eg: *Funaria, Polytrichum, Sphagnum* etc.

Economic Importance

- They are food for herbaceous animals.
- Sphagnum (Moss) - in the form of peat is used as fuel.
- It is also used for trans-shipment of living material because of its water holding capacity
- Prevent soil erosion.
- Along with lichens, they are the first colonizers on barren rocks.
- They decompose rocks making substrate for the growth of the higher plant (Succession).

PTERIDOPHYTES:

The first terrestrial plant possesses vascular tissue like **xylem** and **phloem**. So they are known as vascular cryptogams. **Commonly known as a botanical snake.**
The plant body is differentiated into true root, stem, and leaf.

The plant body is the sporophytic generation.
The stem is rhizomatous and regenerates when aerial parts are destroyed.
Leaves may be small (**microphyll**) as in *Selaginella* or large (**macrophyll**) as in ferns.
The coiling of young leaves is seen in pteridophytes.
Leaves are of two types vegetative and fertile. Fertile leaves are the spore-bearing leaves called sporophylls.
Spores are formed inside the sporangia.
In Sporangia, the spore mother cells give rise to spores after meiosis.
Spores germinate to form haploid gametophytic, photosynthetic heart shapedmulticellular structure called prothallus which bears antheridia and archegonia.
Prothallus requires cool, damp shady areas for growth and water is essential for fertilization.
The antheridia bear **antherozoids** and archegonia bears the **egg cell** respectively which on fertilization form zygote which on germination forms the sporophyte.
Most of the pteridophytes produce similar kinds of spores hence called **homosporous.**
Genera like *Selaginella* and *Salvinia* produce two kinds of spores, macro or large spores and small or microspores, and are said to be **heterosporous**. Microspore and macrospore germinate and gives rise to male and female gametophyte respectively.
In heterosporous conditions the female gametophyte is not free-living, it is retained in the parent sporophyte till the beginning of the embryo development.
Seed bearing plants are evolved from heterosporous pteridophyte.
Pteridophytes further classified into four classes:

- Psilopsida (*Psilotum*)
- Lycopsida (*Selaginella*)
- Sphenopsida (*Equisetum*)
- Pteropsida (*Pteris*).

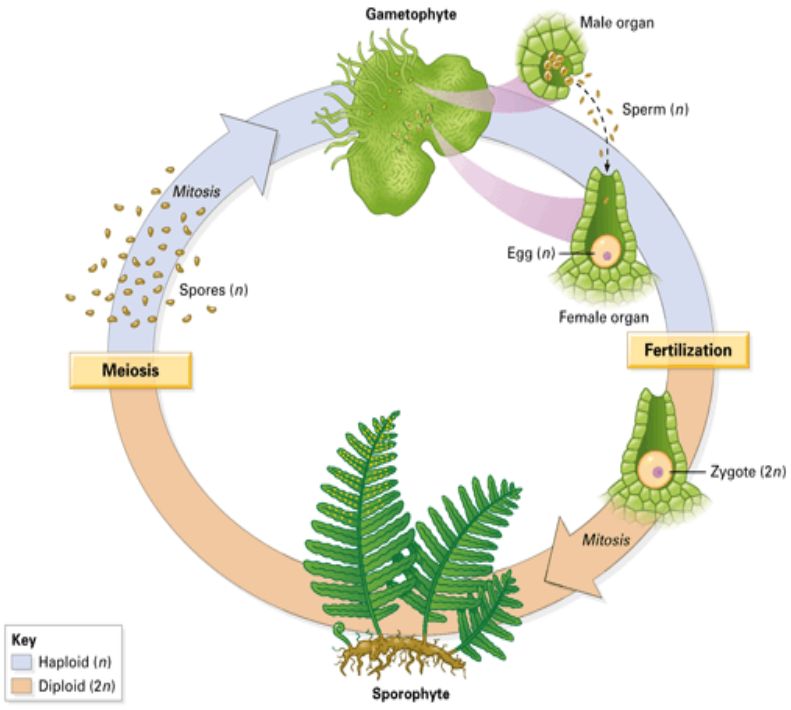
Economic importance:

- Some members are Medicinal- *Dryopteris*
- Helps in Soil binding
- Used as Ornamental plants
- Edible plants- *Marcelia*
- Used in Crop rotation- *Azolla*
- Helps in Symbiotic nitrogen fixation.
- Play an important role in plant succession on bare rocks or soil.
- Sphagnum is used to keep seedlings in gardens and cut plant parts moist during transportation and propagation.

Common names:

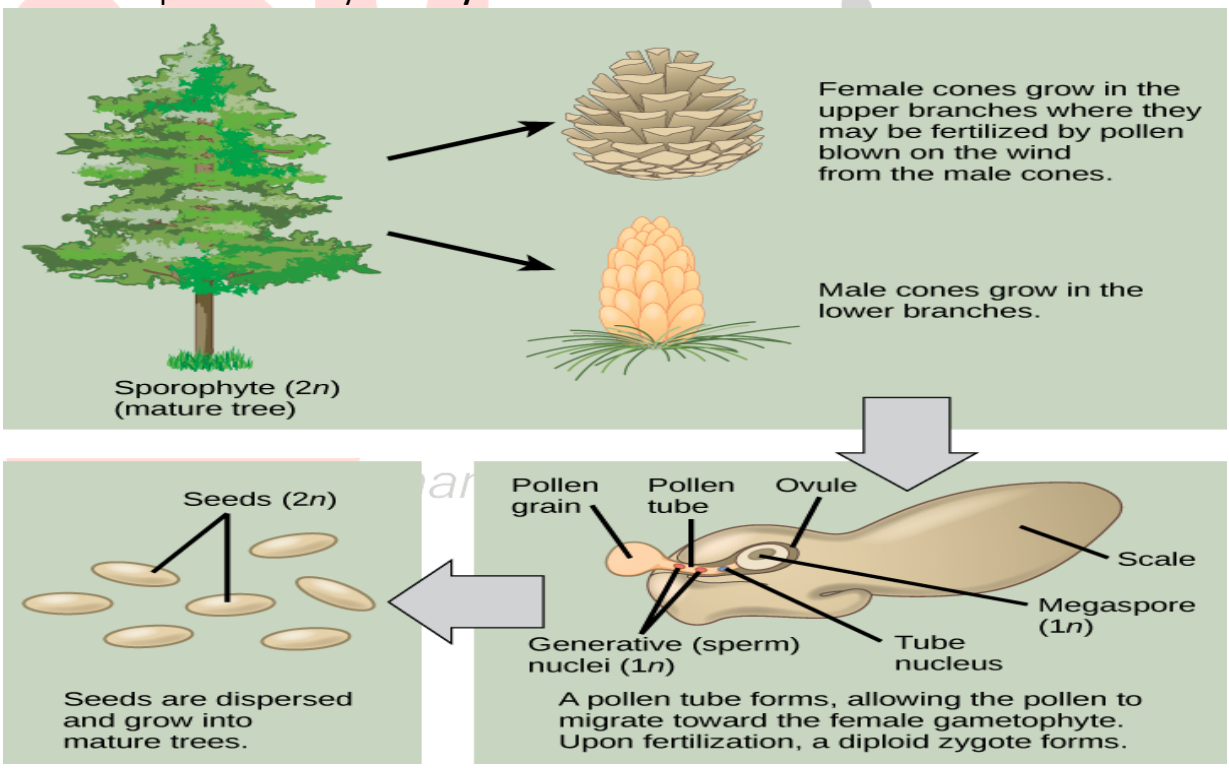
Creeping pine/Club moss- *Lycopodium*
Spike moss(Resurrection plant- *Selaginella*
Water fern- *Azolla* (smallest pteridophyte)
Walking fern (Maiden hall fern)- *Adiantum*

Adder's tongue fern- *Ophioglossum*
Fossil pteridophyte- *Cooksonia*
Leafless Pteridophyte- *Psilotum*
Horsetail- *Equisetum*



GYMNOSPERMS:

Have naked seeds as the ovules are not enclosed by any ovary wall and remain exposed (no fruit covering).
Flowerless seed-bearing plants.
Ovules are not enclosed by the ovary wall.
Dominant plants during the Jurassic period.
Gymnosperm includes medium-sized trees or tall trees and shrub.
The Taproot system is generally present. May be associated with mycorrhiza-Association between fungus and roots of higher plants. Eg: *Pinus*.
Coralloid roots with nitrogen-fixing bacteria as in *Cycas*.
The stem is branched (*Pinus*), or unbranched (*Cycas*).
Leaves are adapted for extreme temperature, humidity, and wind-needle like leaves with thick cuticle, sunken stomata. Eg: *Pinus*.
Leaves may be simple or compound.
Stem is unbranched as in *Cycas* .Branched in *Pinus* and *Cedrus*
Well-developed vascular system –**xylem without vessels.**



REPRODUCTIONS:

- Sporophylls are aggregated to form strobili or cone. They are generally monosporangiate or of two types of male and female cones.
- Male cones are short-lived and female ones are long-lived.
- **Male strobili or male cone – microsporophylls** which bear **microsporangia** having microspores which develop into reduced gametophyte called **a pollen grain**.

- **Female cone or female strobili –megasporophylls** which bear **megasporangium** having **megaspores** which are enclosed within the **megasporangium** (Nucellus).
- One megaspore develops into female gametophyte bearing two or more **archegonia.**
- Pollen grains are carried by wind and reach the ovules.
- They form a pollen tube that reaches the archegonia and releases male gametes into the ovule.
- The fusion of the gametes takes place and the zygote is formed which produces embryos. Ovules develop into seeds that are not covered.
- The endosperms in gymnosperms is a pre fertilization product and haploid in nature.
- The dominant photosynthetic independent stage is the sporophyte. The gametophyte is single to few celled and not free living.

Classified into four classes:

1.Cycadopsida Eg: *Cycas*
2. Coniferopsida eg: *Pinus*
3. Gnetopsida: Eg: *Gnetum*.
4. Gingopsida- *Ginko*

Economic importance:

- Timbers for furniture, Pulpwood, Pencil box, Musical instruments, etc.
- Production of resins, Turpentine etc.-E.g.-*Pinus*
- Edible seeds: Eg- *Cycas, Pinus, Ginkgo*.
- Medicinal Eg: Ephedrine from *Ephedra* (used for respiratory problems)
- Taxol – from *Taxus* species to freeze cancer cells.

Common names:

- Maidenhair tree- *Ginkgo*
- Sago palm /Panda of the plant kingdom- *Cycas*
- Largest gymnosperm- *Sequoia*
- Smallest gymnosperm- *Zamia*
- Gymnosperm with xylem vessels- *Ephedra, Gnetum*.

ANGIOSPERMS:

Angiosperms are known as flowering plants and **have covered seeds**.
They are divided into two classes –
1.Dicotyledons (have two cotyledons)
2. Monocotyledons (have one cotyledon).
Smallest angiosperm: ***Wolfia*** (microscopic).
Large tree: ***Eucalyptus*** over 100 meters.
Reproductive organs developed in **flowers**.
The Male sex organs in a flower are called **stamens** or androecium.

It has **filament** and **anther**. Anthers on meiosis produce **pollen grains**. Pollen grains have two male gametes.

The female reproductive part is the pistil or gynoecium. It has **stigma**, **style,** and **ovary**.

The ovary has one or many ovules in which female gametophyte (**embryo sac**) develops by meiosis.

The embryo sac has 7 cells and 8 nuclei.

- **1 egg cell**
- **2 synergids**
- **3 antipodal**
- **One central cell having two polar nuclei**.

The pollen grain is carried by various agents like wind, water, birds, insects, etc. and reaches the stigma.

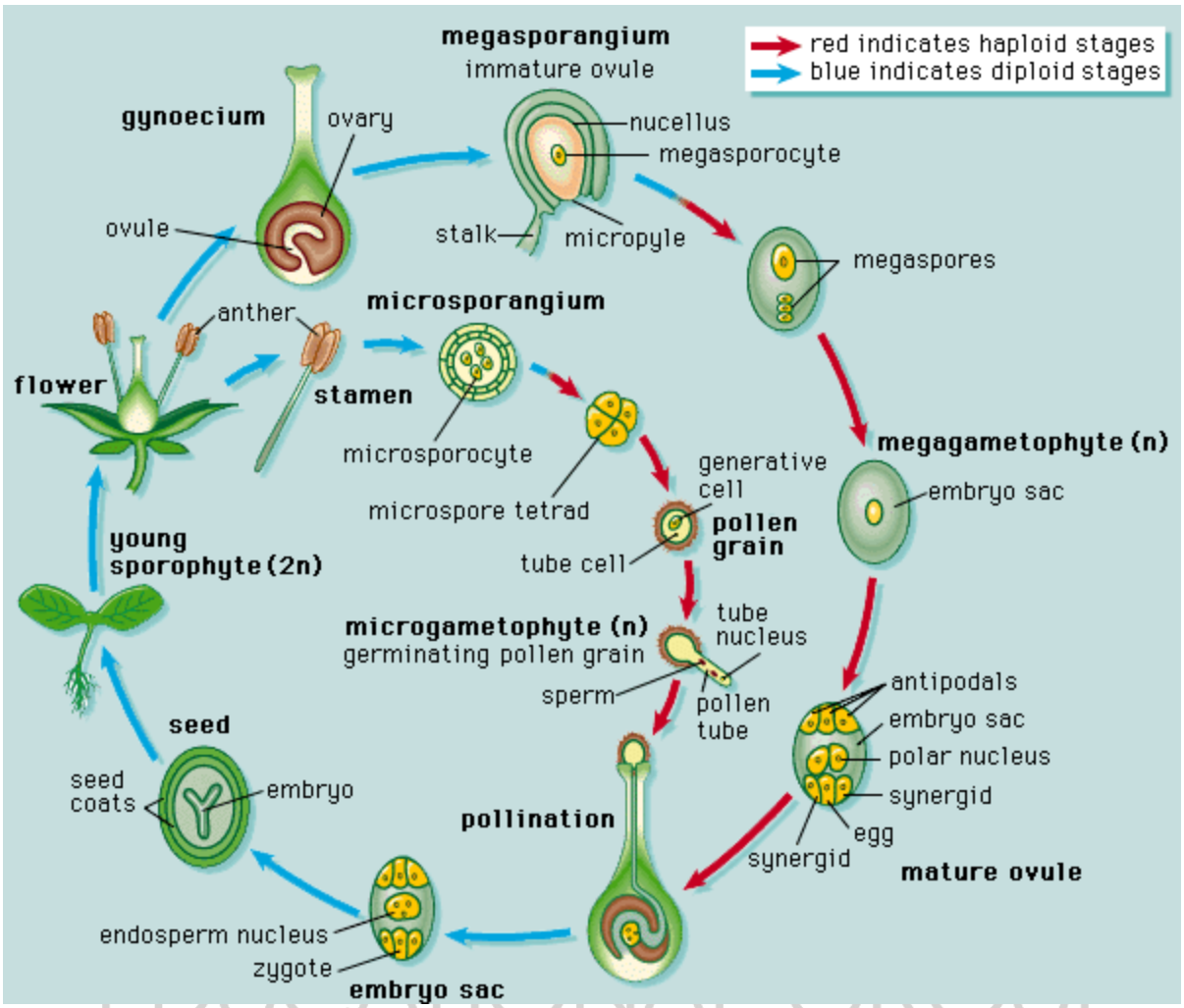
Pollen grains produces a pollen tube that contains two male gametes and enters into the embryo sac.

One male gamete fuses with the egg cell to form a zygote and is called **syngamy** which develops into an embryo.

Other male gamete fuses with a secondary nucleus (formed by the fusion of two polar nuclei) which forms a triploid primary endosperm nucleus (PEN) and is called **triple fusion.** PEN develops into endosperm which nourishes the developing embryo. As two fertilization (syngamy and triple fusion) takes place inside the embryo sac at the same time, it is called double fertilization.

The endosperm is triploid. Ovules develop into seeds and ovaries into fruits.

LIFE CYCLE OF ANGIOSPERMS



ALTERNATION OF GENERATION:

There is an alternation of a haploid gamete producing gametophytic and spore-producing sporophytic generation.

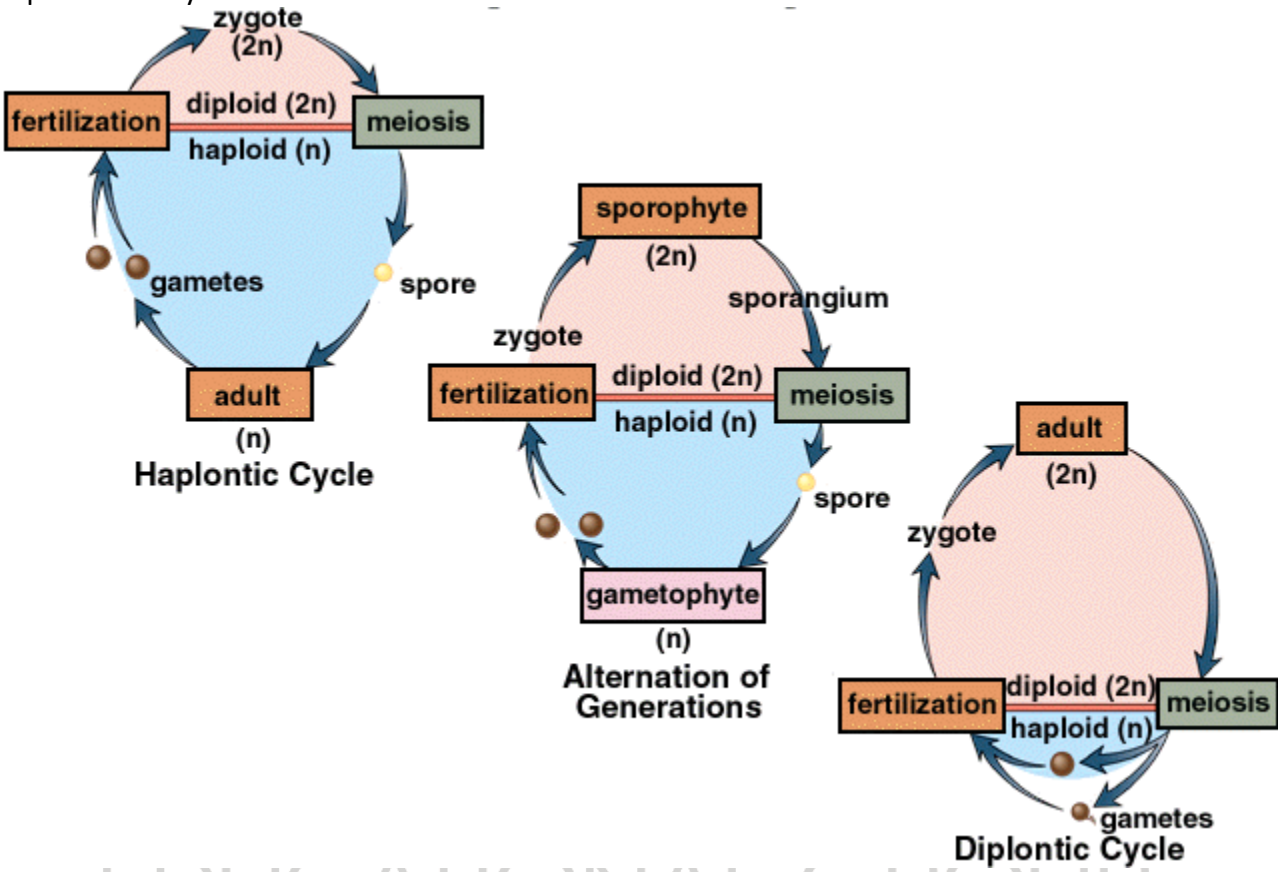
Three types-

1. Haplontic life cycle: In this type, the dominant, photosynthetic phase is a free-living gametophyte produced by haploid spores. The gametophyte produces gametes by mitosis and the gametes fuse to form the zygote which represents the sporophytic generation. The zygote undergoes meiosis to form haploid spores. **Here the Gametophytic phase is dominant**. e.g., *Chlamydomonas*.

2. Diplontic life cycle: Here the diploid sporophyte is the dominant photosynthetic independent phase of the plant. The gametophytic phase is represented by one to few celled haploid gametophytes. Here the **sporophytic phase is dominant**. e.g., Angiosperms and Gymnosperms.

3. Haplo-Diplontic life cycle: In this type, both haploid and diploid phases are multicellular and often free living. Seen in bryophytes and pteridophytes.

Although most algal genera show a haplontic life cycle, some of them such as *Ectocarpus, Polysiphonia*, Kelps, etc. exhibit a haplo-diplontic life cycle. *Fucus* a brown alga exhibits a diplontic life cycle.



IMPORTANT TERMS

photosynthesis

The process by which plants and some other organisms capture and use light energy to make food from carbon dioxide and water.
ex sentence: During photosynthesis light is trapped by chlorophyll.

tissue
A group of similar cells that perform a specific function in an organism.
ex sentence: The dermal is a type of tissue that protects the plant.

chloroplast
A plant cell structure in which photosynthesis occurs.
ex sentence: Chloroplast is when the sunlight gets trapped to make glucose.

vacuole
A large sac-like storage area in a cell.
ex sentence: The vacuole can store substances like sugar and salt.

cuticle
The waxy, waterproof layer that covers the leaves and stems of most plants.
ex sentence: The cuticle of the plant makes it look shiny.

vascular tissue

The internal transporting tissue in some plants that are made up of tube-like structures.
ex sentence: The vascular tissue carries water and nutrients throughout the plant body in higher plants.

fertilization
The joining of a sperm cell and an egg cell.ex sentence: Fertilization of the cells is to create new cells.

zygote
A fertilized egg.
ex sentence: Zygote is the cell that is formed when it accepts the sperm cell.

nonvascular
A low-growing plant that lacks true vascular tissue.
ex sentence: Nonvascular plants cannot transport nutrients throughout the plant easily.

vascular plant
A plant that has true vascular tissue.
ex sentence: Vascular plants can transport nutrients to the plant more easily.
chlorophyll
A green pigment found in chloroplasts of plants, algae, and some bacteria.
ex sentence: The chlorophyll absorbs light energy for photosynthesis.

sporophyte
The stage in the life cycle, of a plant in which the plant produces spores.
ex sentence: Sporophyte is when the plant makes more spores.

gametophyte
The stage in the life cycle of a plant in which the plant produces gametes or sex cells.ex sentence: Gametophyte is when it makes more gametes or sex cells.